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PREPARATION AND EVALUATION OF MECHANICAL PROPERTIES OF AL6061 REINFORCED WITH E-GLASS FIBER METAL MATRIX COMPOSITES

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ABSTRACT

Aluminium alloy materials found to be the best alternative with its unique capacity of designing the material to give required properties. Aluminium alloy metal matrix composites (MMCs) are gaining wide spread acceptance for automobile, industrial and aerospace application because of their low density, high strength and good structural rigidity. In the present work, an attempt is made to prepare and study the mechanical properties of Al6061- E-glass fiber Composite. The Al6061- E-glass fiber having 2wt%, 4wt%, 6wt%, 8wt% and 10wt% were fabricated by liquid metallurgy (stir cast) method. The ingots were subjected to T6 heat treatment to optimize the properties. The composite specimens were machined as per ASTM test standards. The microstructures of the composites were studied to know the dispersion of the E-Glass fiber in matrix. It has been observed that addition of E-Glass fiber significantly improves ultimate tensile strength along with compressive strength and hardness properties as compared with that of unreinforced matrix.

KEYWORDS: Al6061, EDS, E-Glass Fiber, Mechanical Properties, Vortex Method

INTRODUCTION

Metal matrix composites are gaining wide popularity in several sectors due to its improved mechanical properties and lighter density when compared with metal/alloy, especially in application where weight and strength are of prime importance. Al/Al alloy based MMc are being used as a material system in several applications such as pushrods, cylinder, connecting rod, piston and brake disc etc [1]. In Particular, Fiber and Particulate reinforced MMcs have found special interest because of their specific strength and specific stiffness [2]. For these materials, silicon carbide (sic), a commercially pure metal, has become the main type of reinforcement used [3] and most of the research work carried out on aluminium based composite material involves silicon carbide as its reinforcing material.

Al6061 alloy have numerous benefits like formability weld ability, corrosion resistance and low cost. For production of Aluminium particulate reinforced composite stir casting method appears to be promising method among various conventional processing methods. Heat Treatment process to modify the microstructure of aluminium alloy composites with aluminium alloy matrix is the final production stages of composite [4]. Addition of the reinforcement short E-Glass fiber with Al7075 and heat treated shows the increase in tensile and hardness properties [5]. In this present work, an attempt has been made to develop E-Glass-AL6061 alloy. Composite to study the Mechanical Properties by varying the wt% of E-Glass fiber

EXPERIMENTAL PROCEDURE

Material Preparation

The matrix material used for the MMcs in this study Al6061 has excellent casting properties and reasonable strength. This alloy is best suited for mass production of light weight metal castings. Table 1 and Table 2 shows the chemical composition of Al6061 and E-Glass fiber.

Table 1: Chemical Composition of Al6061 by Weight Percentage

Mg (Magnesium)	0.920%
Si (Silicon)	0.750%
Fe (Ferrous)	0.280%
Cu (Copper)	0.220%
Ti (Titanium)	0.100%
Cr (Chromium)	0.070%
Zn (Zinc)	0.060%
Mn (Manganese)	0.040%
Be (Beryllium)	0.003%
V (Vanadium)	0.010%
Al (Aluminium)	Balance

Table 2: Chemical Composition of E-Glass Fiber by Weight Percentage

SiO_2	Al_2O_3	CaO	MgO	B_2O_3
54.3%	15.2%	17.2%	0.6%	0.8%

E-Glass fibers of diameter 4 to 6 µm, in roving form, were bundled and cut into short fibers of 1 to 1.5 mm uniform length by a constant – length cutter. The short glass fiber was cleaned in distilled water and dried at 90° C. Liquid metallurgy technique was used to fabricate the composite materials in which the short fibers were introduced into the molten metal by the use of an alumina- coated stainless steel stirrer. The coating of alumina on the stirrer is essential to prevent the migration of ferrous ions from the stirrer material into the molten metal. The stirrer was immersed to about one – third depth of the molten metal pool from the bottom of the crucible and rotated at 550 rpm. The pre-heated (500°) glass fibers were added into the vortex of liquid melt, which was the degassed using pure nitrogen for about 3 to 4 min. The resulting mixture was tilt poured into preheated permanent mould. E-Glass fiber was varied from 2 to 10% in steps of 2% by weight.

Heat Treatment

The cast Al6061 matrix alloy and Al6061/E-Glass fiber composites were subjected to solutionzing treatment at a temperature 530° for a period of 2 hours using muffle furnace, followed by quenching in water artificial ageing treatment was carried out for duration of 6 hours at 175°.

Metallography

The specimens subjected to optical micrography were first rough polished with a series of silicon carbide papers of 100, 200, 400, 600 and 1000 grit size. Then fine polishing was done using magnesium oxide paste followed by 3 µm thick diamond paste on a velvet cloth. Samples for microscopic examinations were prepared by standard metallographic procedures, etched with keller's reagent and examined under optical microscope.

Testing

As Cast and composite T6 heat-Treatment ingots were machined using CNC lathe to ISO 1608-205 standards to prepare the specimen, the tests were conducted in accordance with ASTM standards. Tensile tests were conducted at room temperature using a Universal Testing Machine in accordance with ASTM E8-82. The Tensile specimens of diameter 6 mm and gauge length 41 mm were machined from the cast composites as shown in figure 1. With the gauge length of the specimen parallel to the longitudinal axis of the castings

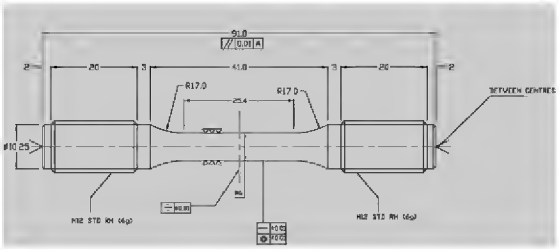


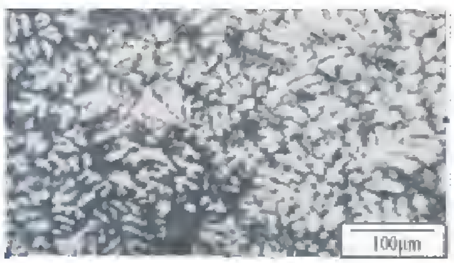
Figure 1: Tensile Specimen with ASTM E-8-82

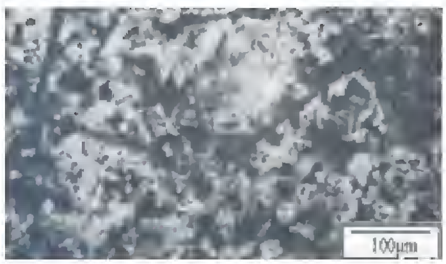
Hardness test were performed on as cast and composites to know the effect of E-Glass fiber in matrix material. The polished specimens were tested using Vickers micro hardness testing system. A load of 1 N for a period of 10 seconds was applied on specimens. The hardness was determined by recording the diagonal lengths of indentation produced. The specimen size is 10. The test was carried out at three different locations and the average valve was taken as the hardness of the as cast and composite specimens.

RESULTS AND DISCUSSIONS

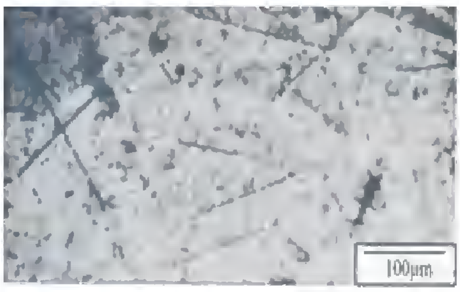
Microstructure Analysis

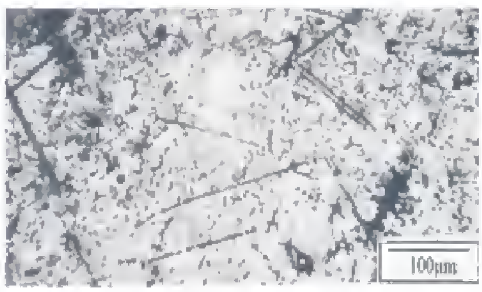
The optical photomicrographs of the fabricated AMCs are shown in figure 2. It is observed from the figure the E-Glass fibers are dispersed uniformly in aluminium matrix at different weight percentage. The size of the E-Glass fiber appears to be uniform throughout the aluminium matrix. This can be attributed to the effective stirring action and the use of appropriate process parameters. Homogeneous distribution of particle is to enhance the mechanical properties of Alloy.



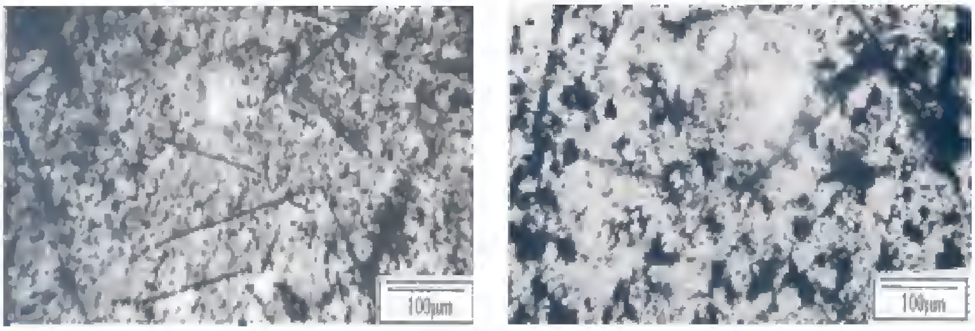


(a) **(b)**





(c) **(d)**



(e) (f)

Figure 2: The Microstructure of the Different Specimens Containing Different Weight 0%, 2%, 4%, 6%, 8% and 10% of Al6061 Reinforced with E-Glass Fiber

DISPERSIVE X-RAY SPECTROMETRY (EDS)

The EDS profiles of the fiber in the composites produced, some of which are presented in Figure 3 shows peaks of aluminium (Al), and magnesium (Mg), silicon (Si), iron (Fe), Argon (Ag).

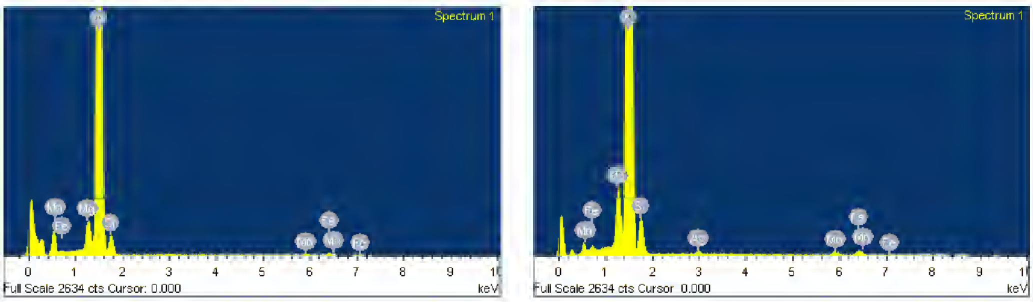


Figure 3: EDS Spectrum and the Average Chemical Composition of E-Glass Reinforced with Al6061

TENSILE STRENGTH

Figure 4 shows the effect of Ultimate tensile strength of composites containing various amounts of E-Glass fibers. It can be seen that as the glass content increases, the ultimate tensile strength of the composite material increases. Weld ability is one of the dominating factors to ensure good bonding between the matrix and reinforcement [6]. A good bonding between reinforcement and soft aluminium matrix favors an enhancement of the ultimate tensile strength of the composite [7]. As more glass fibers were added, decreases in inter-fiber distance between hard glass fibers causes an increase in dislocation pile-up.

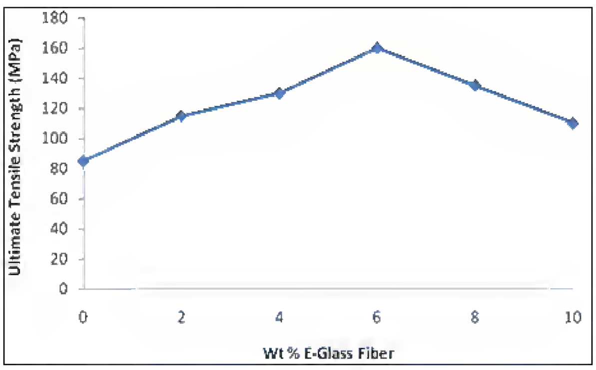


Figure 4: Effect of E-Glass wt % on Tensile Property of Composites

COMPRESSIVE STRENGTH

Figure 5 shows the relation between weight percentage of E-Glass fiber and compressive strength of fabricated composite. Increase in the E-Glass fiber increases the compressive strength of the composites. This is due to the interface and effective transfer of applied compressive load to the uniformly distributed well bonded reinforcement. Similar results were demonstrated in various studies made on the compressive strength of composite materials [8, 9].

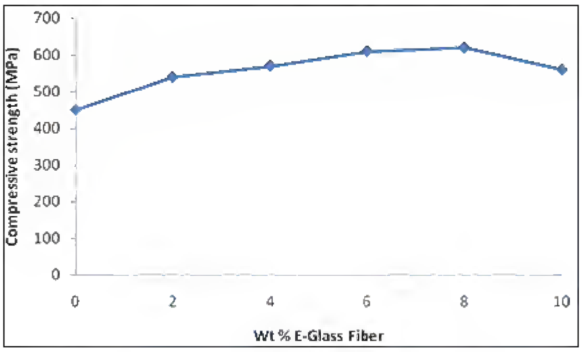


Figure 5: Effect of E-Glass wt % on Compressive Strength of Composites

MICRO HARDNESS TEST

Figure 6 shows the relation between weigth percentage of E-Glass fiber and hardness of fabricated composites it is evident that the hardness of the composite material is much higher than that of its parent metal. It also shown that the hardness of the composite material increases with wt% of E-Glass content. This is because of addition of reinforcement makes the ductile Al6061 alloy into more brittle and hard silica content increases.

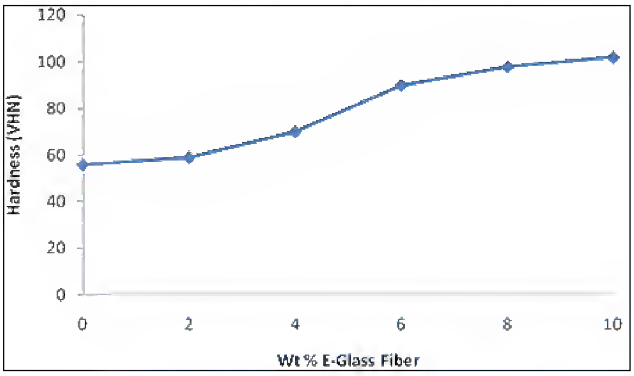


Figure 6: Effect of E-Glass wt % on Hardness of Composites

CONCLUSIONS

Based on the study conducted on the E-Glass containing Al6061 composite material, the following conclusions can be made:

- Using stir casting method, E-Glass fiber can be successfully introduced in the Al6061 alloy matrix to fabricate the composite material.
- From the microstructure analysis it is evident that the composite fabricated have fairly even distribution of reinforcements in the composite material.
- Addition of E-Glass fiber significantly improves ultimate tensile strength of Al6061, when compared with that of

unreinforced matrix. However the ultimate tensile strength begins to decrease above 6wt% of E-Glass fiber.

- Addition of E-Glass fiber significantly or clearly improves the compressive strength of Al6061, when compared with that of unreinforced matrix. However the compressive strength begins to decrease above 8wt% of E-Glass fiber.
- The Hardness of the specimen increased with the increase in reinforcement content in the composite. Heat treatment and aging has significant effect on hardness.

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